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RESEARCH MEMORANDUM

FLIGHT CHARACTERISTICS OF A WINGLESS ROCKET-POWERED MODEL WITH FOUR EXTERNALLY MOUNTED AIR-TO-AIR MISSILES AT MACH NUMBERS FROM 0.7 TO 1.6

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

A flight investigation of four air-to-air missiles mounted by pylons on a rocket-powered basic wingless buffet-research vehicle has been made to determine trim, buffet, and drag characteristics of this type of combination. The air-to-air missiles are scaled and mounted in such a way as to represent an interceptor airplane having pylon-mounted missiles on the fuselage lower surface. No severe nor abrupt trim change and very low buffeting was encountered during the test of this configuration. The total missile-plus-interference drag coefficient of four missiles (based on the frontal area of four missiles) is approximately 40 percent greater than the drag coefficient of the isolated missile between the Mach numbers of 0.9 and 1.1, while the total missile-plus-interference drag is 7 percent greater below a Mach number of 0.9, and some favorable interference drag seems to be present above a Mach number of 1.1. Comparison with previously published data indicates that the interference drag of this particular arrangement of externally mounted missiles is a smaller percentage of the missile-alone drag than is the interference drag of any of the several arrangements and shapes of single fuselage-mounted tank or bomb-type stores.

INTRODUCTION

Some types of present-day airplanes must rely on externally mounted fuel tanks for extra fuel and missiles for armament. External mountings to the wings and fuselage of airplanes frequently cause severe buffeting and also increase the airplane drag. In reference 1 a study was made of the effects on buffeting and drag of configurations incorporating various mountings of large external tank or bomb-type stores on a wingless rocket-propelled fuselage. Previous work (refs. 2 and 3) has been done on missiles mounted by pylons to the wings of unswept, swept, and delta wing configurations.

As part of the buffet test program of the Langley Pilotless Aircraft Research Division, an investigation was conducted to determine trim, buffet, and drag characteristics of four scaled models of an air-to-air missile mounted on pylons to the lower surface of a wingless rocket-propelled fuselage. This arrangement was selected to simulate full-scale missiles mounted on an interceptor-type airplane.

SYMBOLS

A — cross-sectional area of configuration at any station, sq ft

C_D — total drag coefficient based on fuselage cross-sectional area, $\dfrac{\text{Drag}}{qS_f}$

C_{D_m} — drag coefficient of one missile alone based on missile cross-sectional area, $\dfrac{\text{Missile drag}}{qS_m}$

ΔC_D — incremental drag of air-to-air missiles and pylons based on total cross-sectional missile area, $\dfrac{S_f}{4S_m}\left(C_{D_{\text{with missiles}}} - C_{D_{\text{without missiles}}}\right)$

$C_{N_{trim}}$ — trim normal-force coefficient, $\dfrac{\text{Normal force}}{qS_t}$

$C_{Y_{trim}}$ — trim side-force coefficient, $\dfrac{\text{Side force}}{qS_t}$

Δg — buffet increment, g units

L — fuselage length, ft

M — Mach number

q — free-stream dynamic pressure, lb/sq ft

R — Reynolds number

S_f — cross-sectional area of fuselage, 0.307 sq ft

S_m cross-sectional area of one missile, 0.00216 sq ft

S_t total area of tail surface in one plane, 1.531 sq ft

MODELS, INSTRUMENTATION, AND TESTS

Models

A sketch of the complete model showing the principal dimensions and the location of the air-to-air missiles is presented in figure 1. Fuselage coordinates and geometric characteristics of the tail are tabulated in tables I and II, respectively. The fuselage-tail configuration minus the missiles is the basic buffet-research vehicle of reference 4 with 6-percent-thick tail surfaces. Figure 2 shows the dimensions of one of the air-to-air missiles with the pylon used in this investigation. The variation of the longitudinal distribution of cross-sectional area with the percentage of fuselage length is shown in figure 3. A series of photographs showing three different views of the air-to-air missiles mounted by pylons to the fuselage is presented in figure 4. The model weight during the test flight was 63.87 pounds.

Instrumentation

The model of this test had two longitudinal accelerometers placed in the nose of the fuselage. One of these accelerometers measured a high range of accelerations while the other measured a low range of accelerations for more accurate subsonic drag data. This model also had a normal and a transverse accelerometer located in the nose of the fuselage and a normal and a transverse accelerometer located near the root quarter-chord station of the tail.

All normal and transverse accelerometers had natural frequencies from 90 cps to 110 cps and from 50 percent to 60 percent critical damping.

Tests

Shake tests were performed on this model to determine its approximate, natural structural frequencies. The approximate natural frequencies and modes of vibration found for this model are presented in the following table.

Modes	Frequency, cps
Fuselage-fin first bending	110
Fuselage-fin intermediate bending	155
Fuselage-fin torsion	280
Missile-tail bending	310
Missile-nose bending	395

This model was accelerated to approximately $M = 1.64$ by an external booster and a sustainer rocket motor. The accelerometer data were received and recorded continuously by the standard NACA telemetering system, and the velocity and flight path were obtained by using the CW Doppler and SCR 584 radar sets. The variation of Reynolds number and dynamic pressure with Mach number is shown in figure 5. This flight test was performed at the Langley Pilotless Aircraft Research Station at Wallops Island, Va.

ACCURACY

The minimum buffet amplitudes, based on the width of the recorded accelerometer traces and the calibration data for the individual instruments, were estimated to be of the order of ±0.05g. The total drag coefficients calculated from the longitudinal accelerometers in the model and from the CW Doppler radar were in good agreement. The maximum error in the total drag coefficient is estimated to be ±0.01 at subsonic speeds and ±0.005 at supersonic speeds. Maximum errors of the normal- and side-force coefficients were estimated to be ±0.02 at subsonic speeds and ±0.01 at supersonic speeds. Mach numbers are estimated to be accurate within 2 percent at subsonic speeds and within 1 percent at supersonic speeds.

RESULTS AND DISCUSSION

The results of this investigation consist of trim normal- and trim side-force coefficients, accelerations due to buffeting, and drag coefficients at trim conditions plotted against Mach number.

Trim

The variations of trim normal-force coefficient and trim side-force coefficient with Mach number are presented in figure 6. These trim data show that there was no abrupt or severe trim change and that the trim levels were near zero throughout the Mach number range in both the normal and transverse planes. These trim data are presented primarily to show the range of lift and side-force coefficients at which the buffeting and drag were obtained.

Buffeting

Sections of the actual telemeter records for this model are reproduced in figure 7 to show the buffet characteristics on the accelerometer traces near $M = 1.0$. All the accelerometers on which the buffet intensities were recorded were located in the fuselage, two near the tail and two near the nose. Due to the size of the missiles, no accelerometers could be placed in them; therefore, the actual buffet intensity of these external mountings could not be recorded at the probable source.

The variations of the normal and transverse buffet intensities with Mach number are shown in figure 8. These buffet-intensity data were obtained by visual analysis of the records shown in figure 7 and are presented herein as the amplitude of the oscillating accelerations due to buffeting. These buffet intensities have been corrected for the amplitude response of both the accelerometer and the recorder at the predominant frequencies encountered. The combined amplitude response factors ranged from about 0.45 to 1.05.

The basic fuselage-tail configuration (ref. 4) used in this test was free of any low-lift buffeting at the Mach numbers encountered; therefore, any buffeting that is present can be attributed to the presence of external mountings on the basic configuration.

Very low buffet intensity in both the normal and transverse planes was encountered throughout the test Mach number range as shown in figure 8. Buffeting was picked up on the normal and transverse accelerometers in both the nose and the tail, with the first bending frequency of the fuselage fin predominating. The points on figure 8 are scattered, but that does not indicate intermittent buffeting since the points shown are the points at which a definite frequency could be observed by visual analysis of the accelerometer record. It is believed that the oscillating amplitudes measured at these definite frequencies were the maximum buffet amplitudes actually experienced by the accelerometers.

Drag

The total drag coefficients of the basic model (ref. 4) and of the present model having four externally mounted air-to-air missiles are plotted against Mach number in figure 9. These drag coefficients are based on the maximum cross-sectional area of the fuselage. The drag shown herein was measured at trim conditions sufficiently low that drag due to lift could be neglected. No adjustments for pylon drag have been made in the data presented herein.

In figure 9 it was seen that the addition of the four fuselage-mounted missiles and pylons to the basic body increased the total drag throughout the Mach number range. This drag increment due to the air-to-air missiles and pylons is shown in figure 10, which presents the variation with Mach number of the total missile-plus-interference drag coefficient based on the frontal area of four missiles. The drag coefficient of one missile alone, based on the frontal area of one missile, is also shown in figure 10. A comparison of these two curves shows that the drag coefficient of four missiles is approximately 40 percent greater than the drag coefficient of the isolated missile between the Mach numbers of 0.9 and 1.1. Below $M = 0.9$ the drag coefficient of four missiles is approximately 7 percent greater than the drag coefficient of the isolated missile, while at supersonic speeds some indication of favorable interference drag seems to be present.

The ratio of the missile-plus-interference drag coefficient to the isolated-missile drag coefficient is plotted against Mach number in figure 11. Since this is a ratio between these two coefficients, unity would indicate no interference. In comparing this ratio with a similar ratio of reference 1 for externally mounted tank or bomb-type stores on the same fuselage, it is interesting to note that, while the isolated missile with a blunt nose and many fins has a high drag coefficient compared to the aerodynamically smooth and finless isolated stores, the interference drag of these four missiles mounted as they are in this test is a smaller percentage of the missile alone drag than is the interference drag of any of the several arrangements and shapes of single external fuselage-mounted tank or bomb-type stores mentioned in reference 1.

CONCLUDING REMARKS

Results of a flight investigation of four air-to-air missiles mounted by pylons on a basic buffet-research fuselage and tail arrangement indicates that the following remarks apply to trim, buffet, and drag characteristics of the configuration: No severe nor abrupt trim change and very low buffet intensity was experienced with the addition of four air-to-air missiles. The total missile-plus-interference drag coefficient of the four missiles (based on the frontal area of four missiles) is approximately 40 percent greater than the drag coefficient of the isolated missile between the Mach numbers of 0.9 and 1.1, while the total missile-plus-interference drag is 7 percent greater below a Mach number of 0.9, and some favorable interference drag seems to be present above a Mach number of 1.1. Comparison with previously published data indicates that the interference drag of this particular arrangement of externally mounted missiles is a smaller percentage of the missile-alone drag than is the interference drag of any of the several arrangements and shapes of single fuselage-mounted tank- or bomb-type stores.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., November 3, 1954.

REFERENCES

1. Mason, Homer P., and Henning, Allen B.: Effects of Some External-Store Mounting Arrangements and Store Shapes on the Buffet and Drag Characteristics of Wingless Rocket-Powered Models at Mach Numbers From 0.7 to 1.4. NACA RM L54I20a, 1954.

2. Silvers, H. Norman, and Alford, William J., Jr.: Investigation at High Subsonic Speeds of the Effect of Adding Various Combinations of Missiles on the Aerodynamic Characteristics of Sweptback and Unswept Wings Combined With a Fuselage. NACA RM L54D20, 1954.

3. Conrard, Donald: Lift, Drag, and Pitching Moment of Low-Aspect-Ratio Wings at Subsonic and Supersonic Speeds - Plane Triangular Wing of Aspect Ratio 3 With Air-to-Air Missile Models Mounted Externally. NACA RM A52C10a, 1952.

4. Mason, Homer P., and Gardner, William N.: An Application of the Rocket-Propelled-Model Technique to the Investigation of Low-Lift Buffeting and the Results of Preliminary Tests. NACA RM L52C27, 1952.

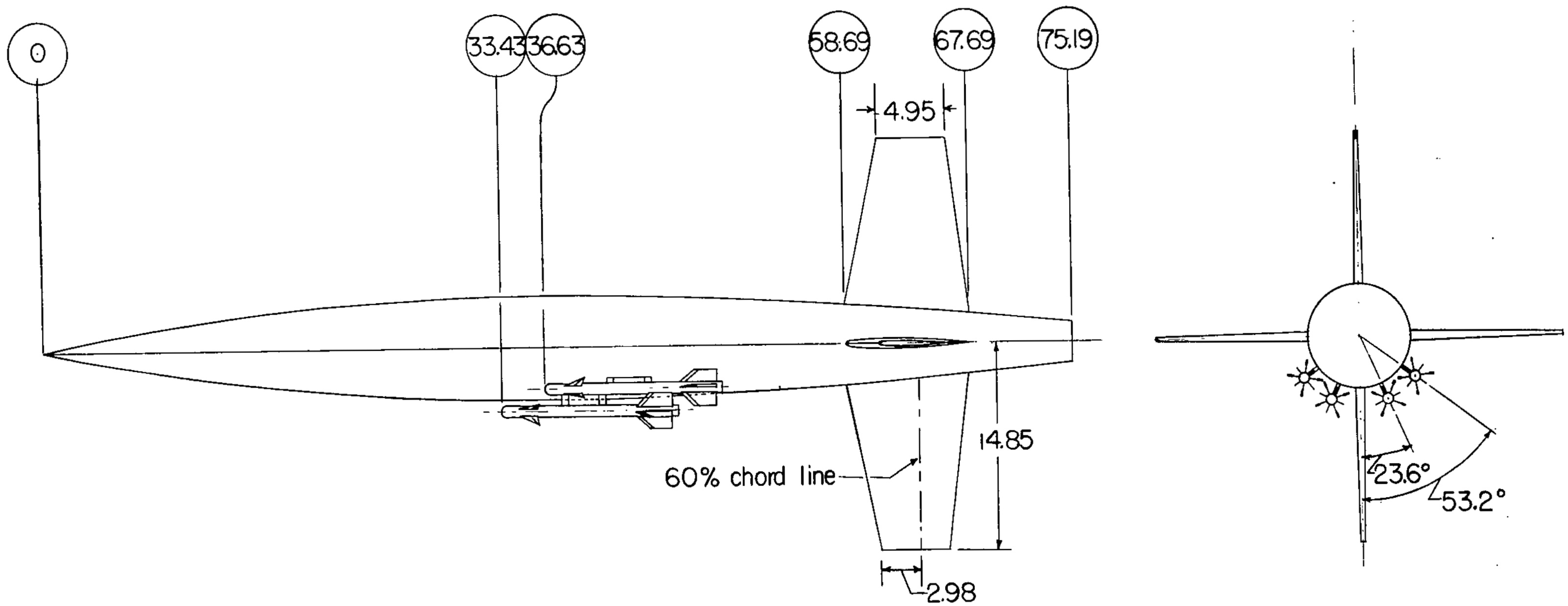


Figure 1.- Sketch of basic model showing principal dimensions and location of air-to-air missiles. All dimensions in inches.

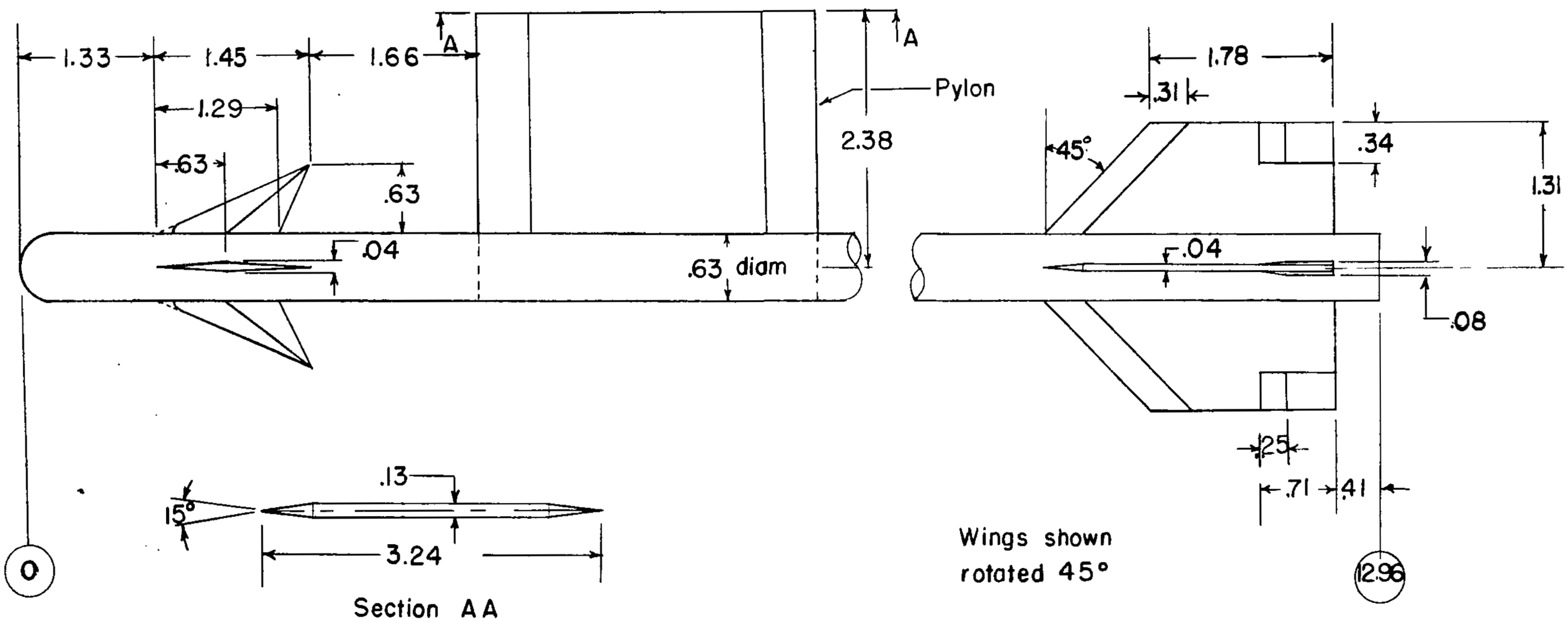


Figure 2.- Sketch of air-to-air missile used on basic model. All dimensions in inches.

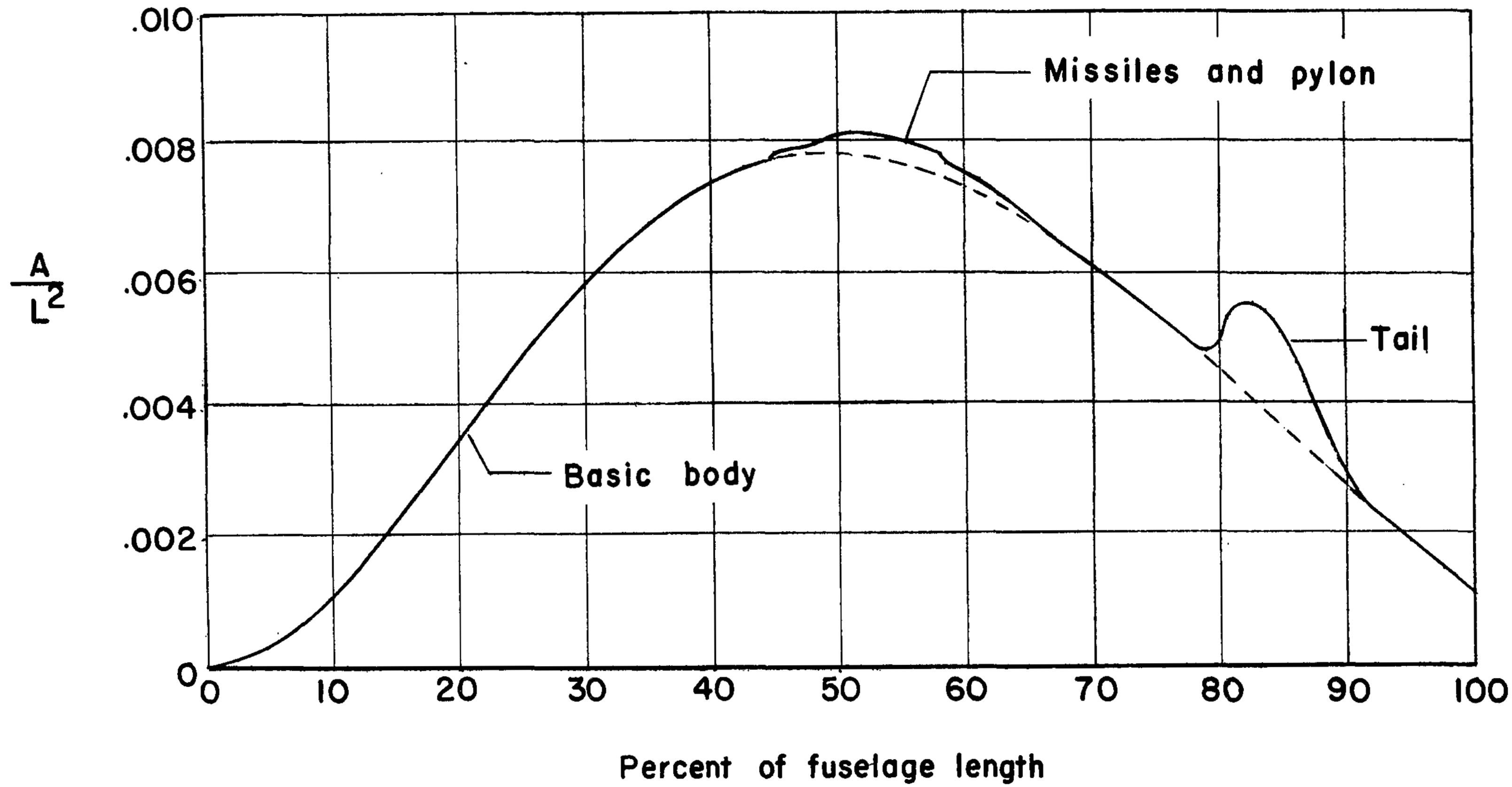
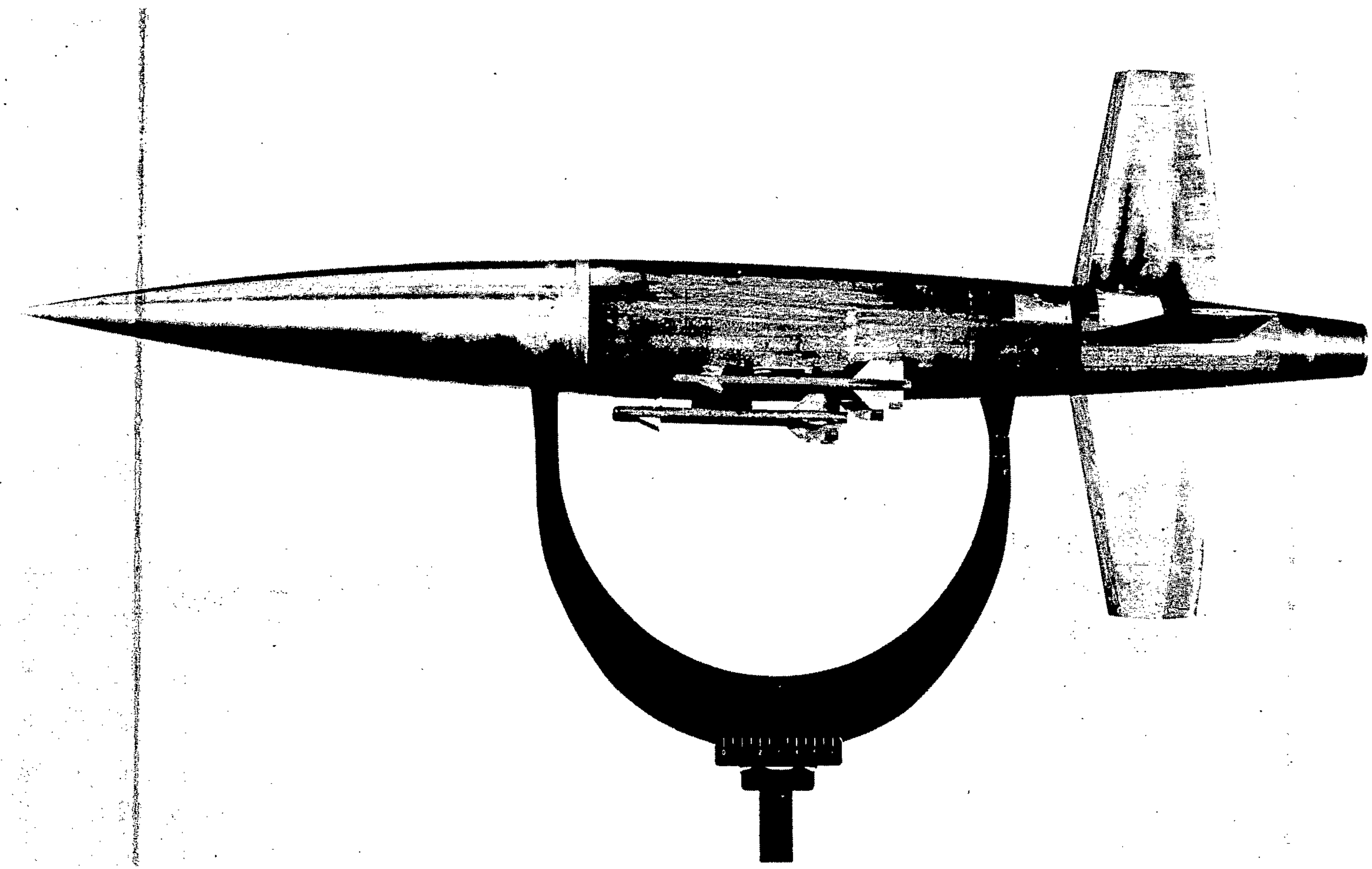
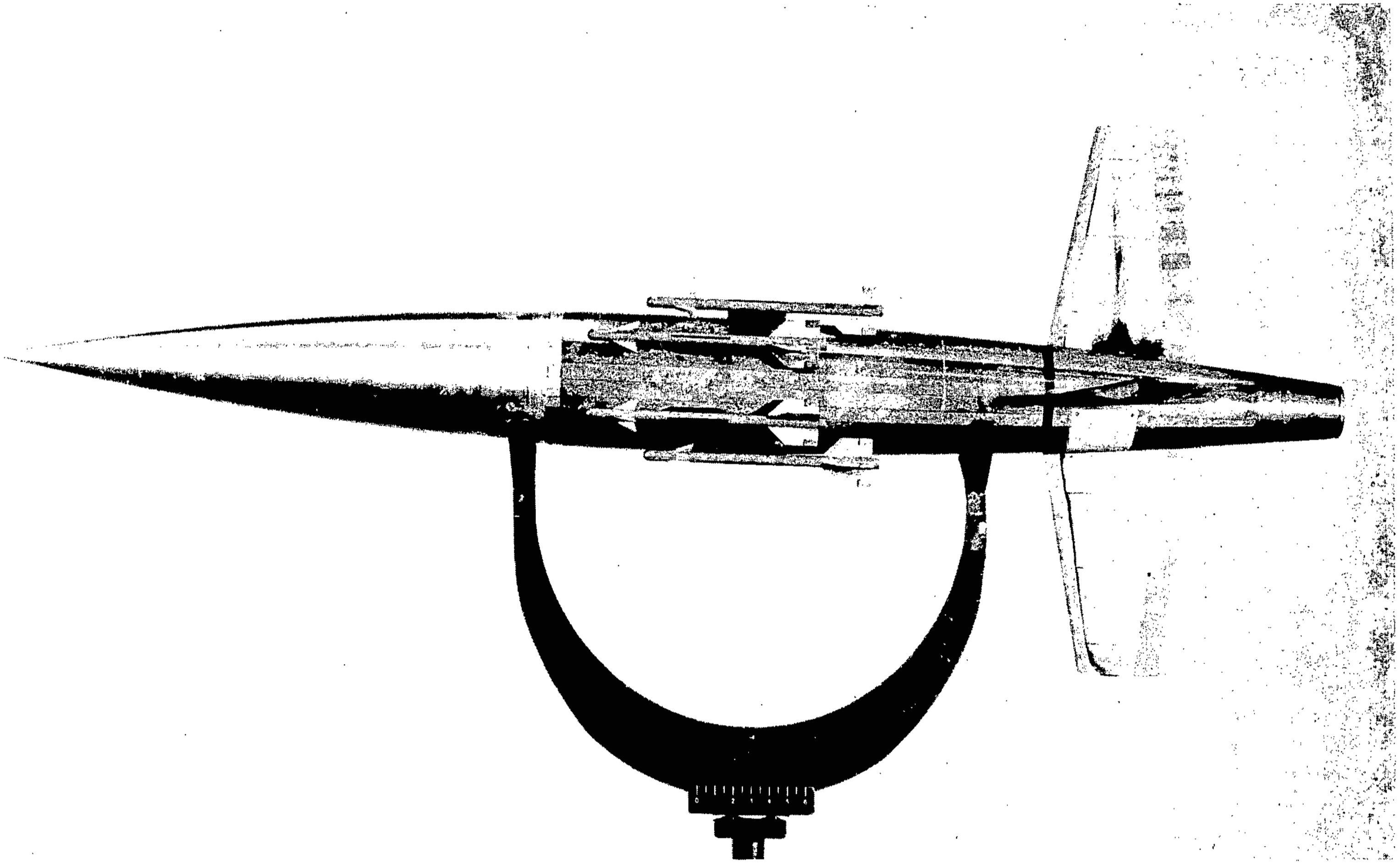


Figure 3.- Longitudinal distribution of cross-sectional area.



(a) Side view. L-85174.1

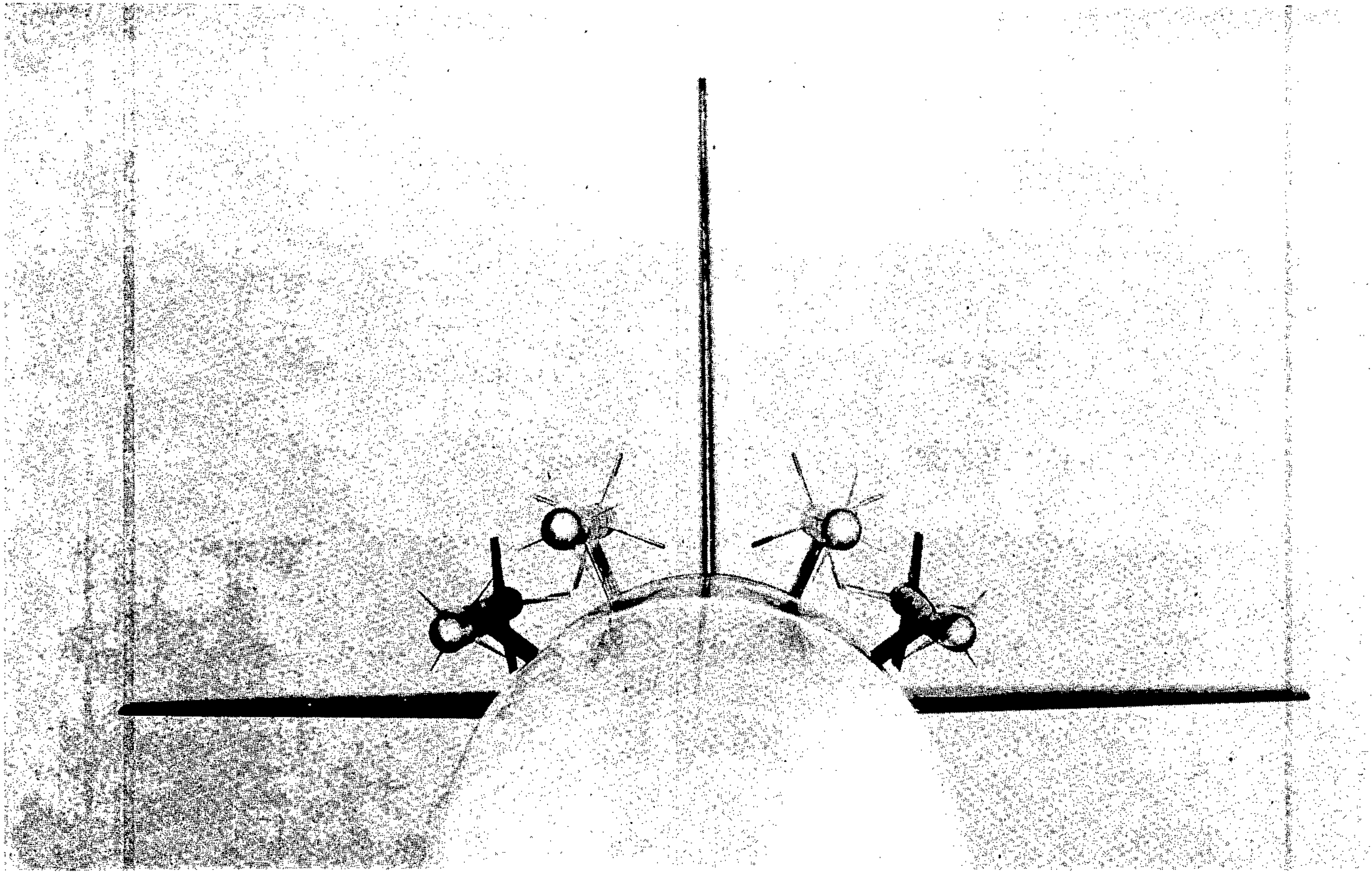
Figure 4.- Photographs of model with air-to-air missiles.



L-85175

(b) Bottom view.

Figure 4.- Continued.



(c) Front view. L-85176

Figure 4.- Concluded.

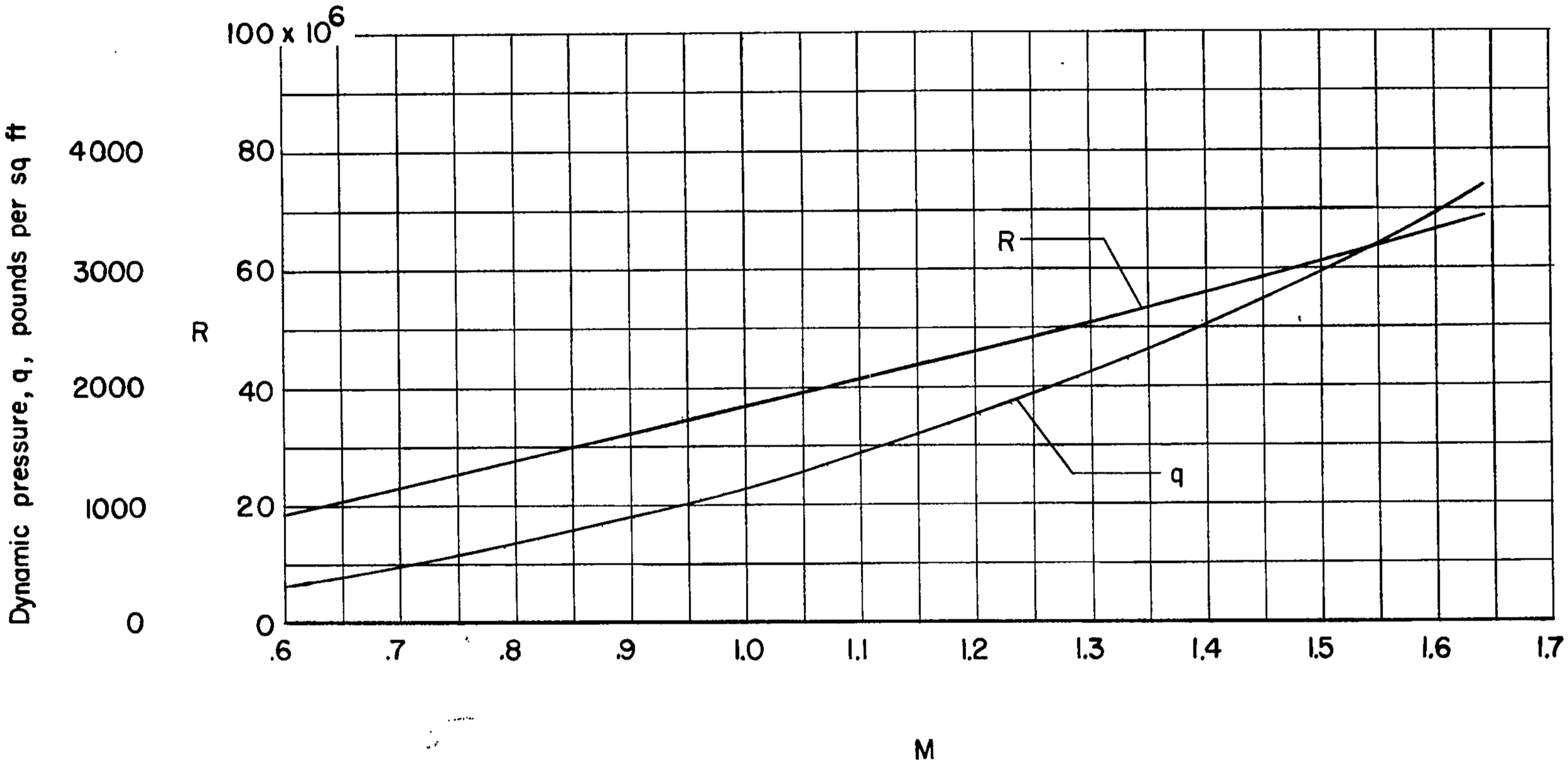


Figure 5.- Variation of dynamic pressure and Reynolds number, based on body length, with Mach number.

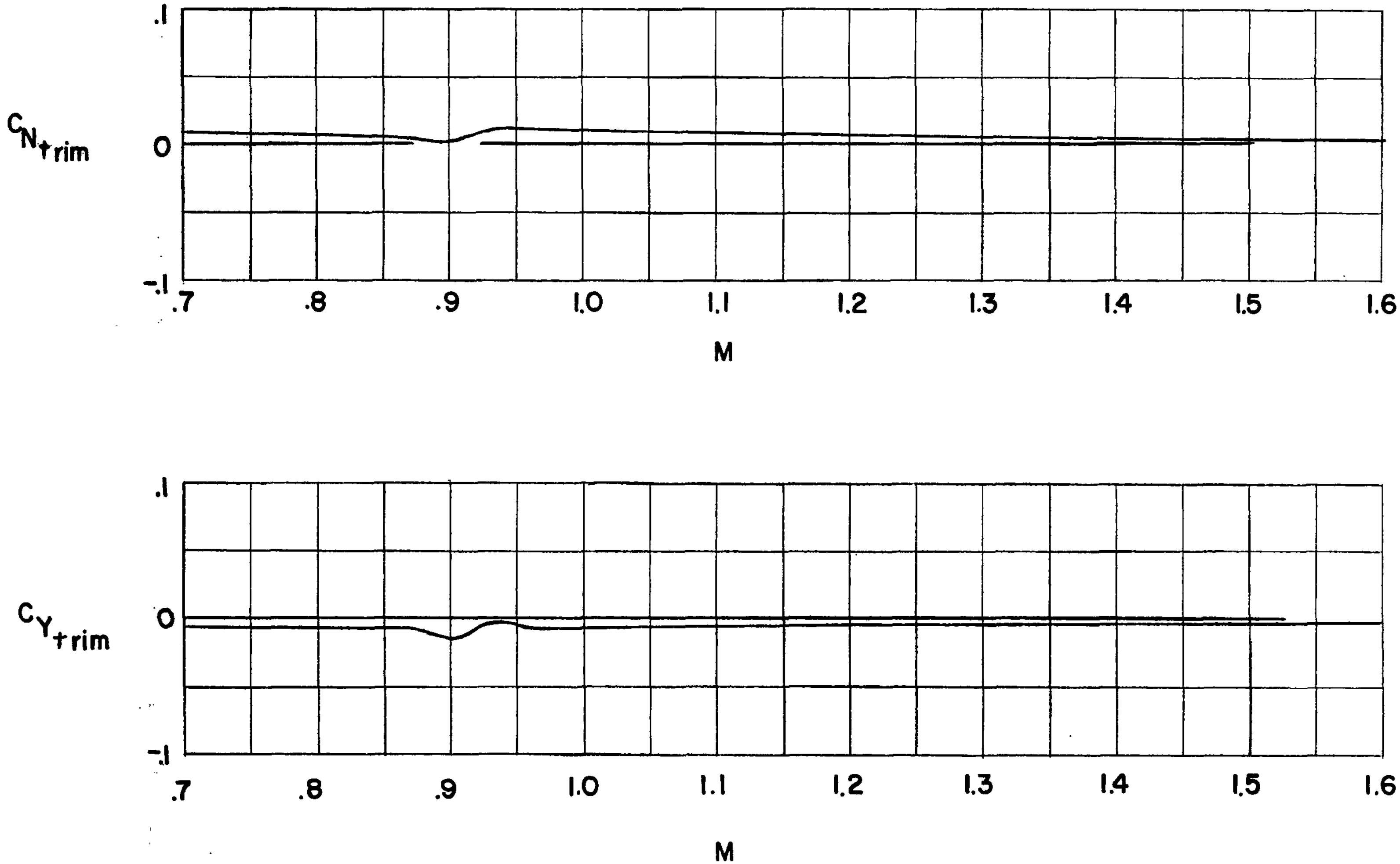


Figure 6.- Variations of trim normal-force coefficient and trim side-force coefficient with Mach number.

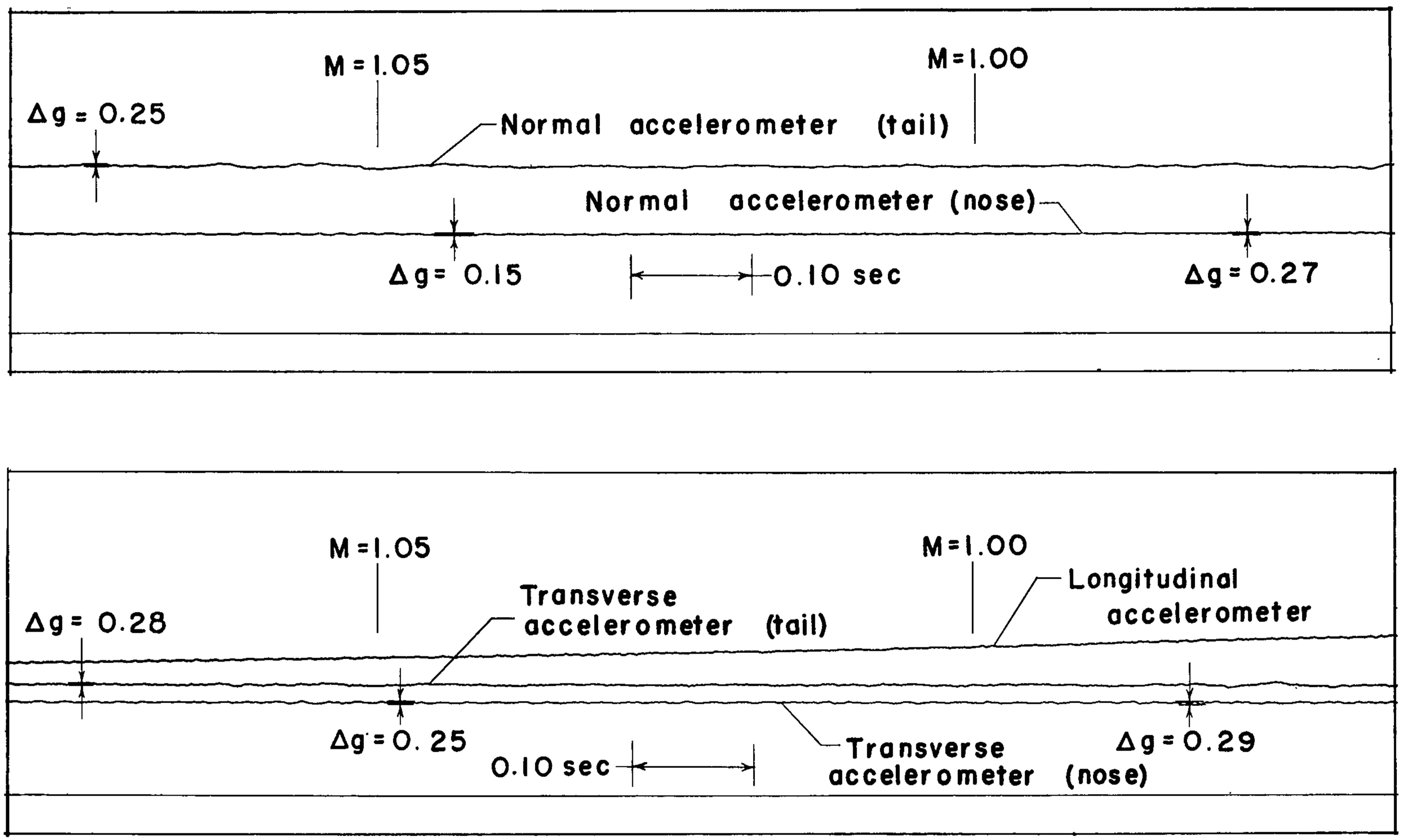


Figure 7.- Parts of actual telemeter records showing accelerometer traces.

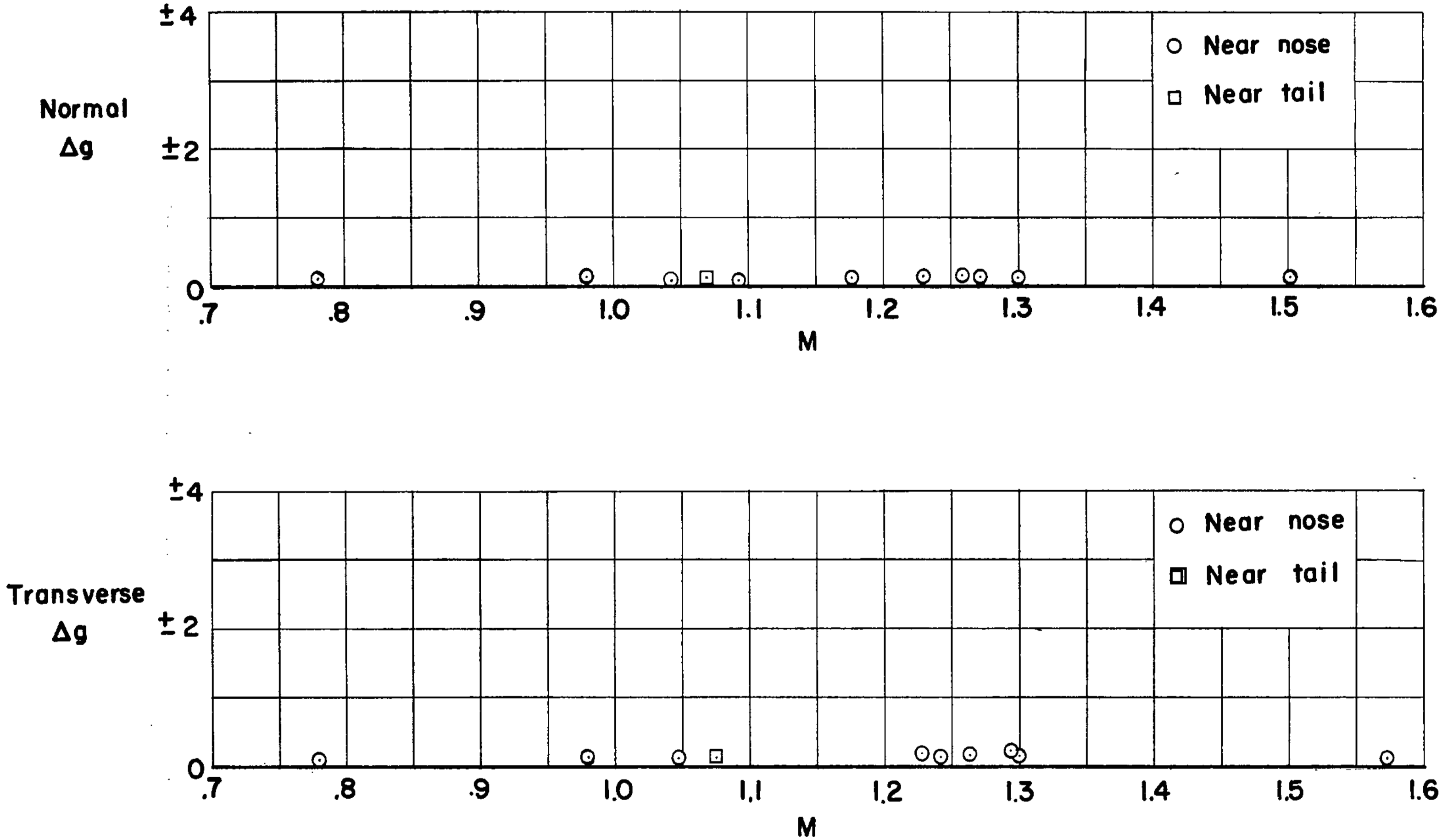


Figure 8.- Variations of normal and transverse buffet intensity with Mach number.

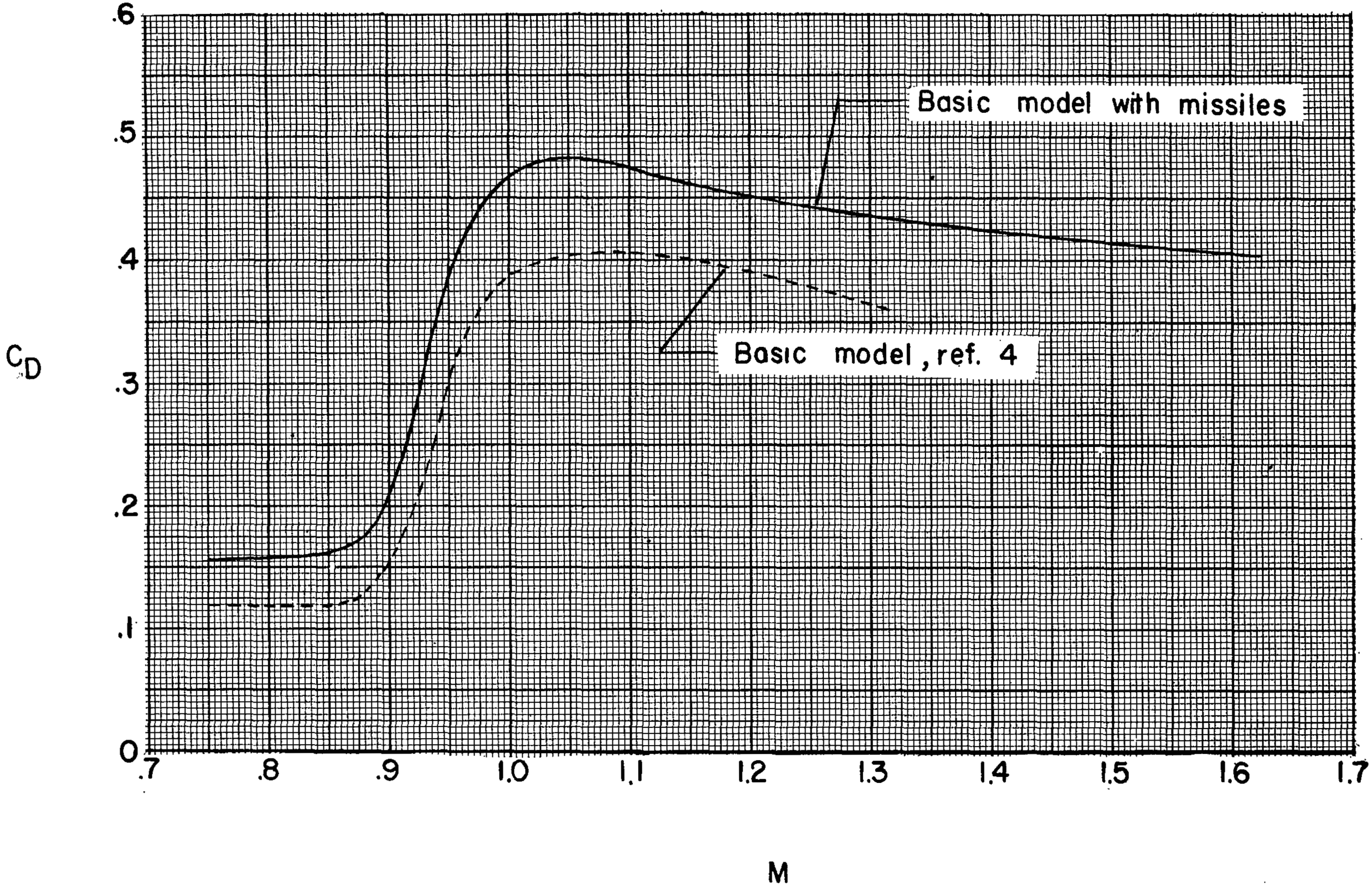


Figure 9.- Variation of total drag coefficient with Mach number. Drag coefficient is based on maximum fuselage cross-sectional area.

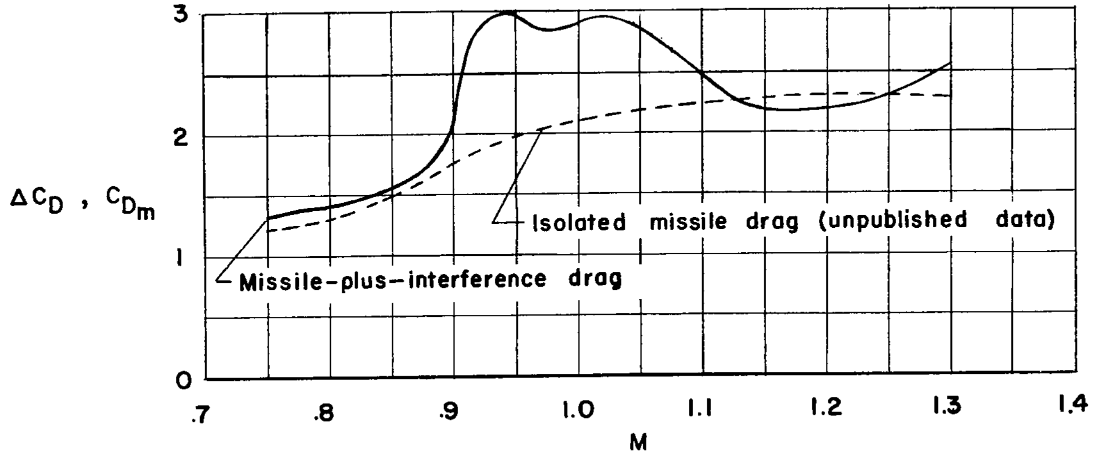


Figure 10.- Variation with Mach number of total missile-plus-interference drag coefficient, based on frontal area of total missile installation, and drag coefficient of one isolated missile based on cross-sectional area of one missile.

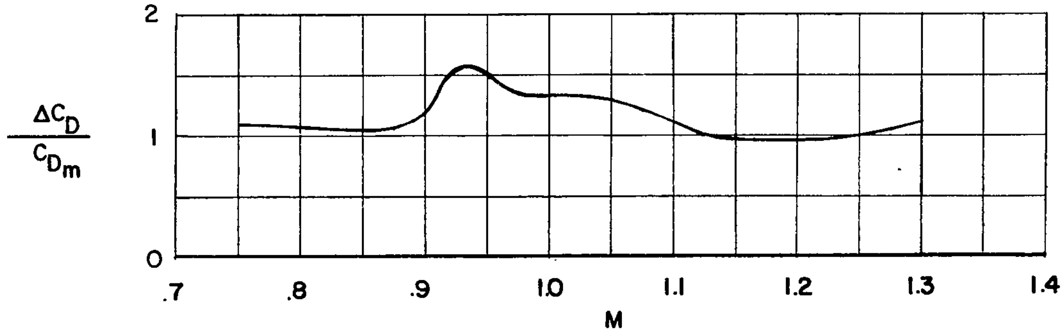


Figure 11.- Variation with Mach number of ratio of total missile-plus-interference drag coefficient to drag coefficient of one isolated missile.